

# NUTRIENT MANAGEMENT IN SUGAR BEET: A REVIEW

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## ABSTRACT

Sugar is an important source of energy for the human body although it receives blame for many health problems, without it, the body would cease to function properly. Nearly thirty percent of the world sugar comes from sugar beet. Production of sugar beet globally spans diverse regions with a wide range of climatic and agro-ecological regions which shows exclusive management challenges. Fertilizer or nutrient management is one of the practices that associate with fertilizer use efficiency and production of the crops including sugar beet. As the nutrient management interacts with different agro-ecological areas and soils, the fertilizer recommendations and management have become regional and site-specific. Maximizing beet and sugar yields, the knowledge of the management of the fertilizers or nutrition is very essential. This article is to understand the impact of different fertilizers in different management practices including the major nutrients of the crop, fertilizer rate, timing, and method of application either solely or in a mixture or integrated manner with reviewing diverse research experiments. Moreover, it will help to approach future strategies and needs for making the production of sugar beet as a cost-effective crop with new improving management technologies for the farmers.

**Key words:** Sugar crop, fertilizer, nutrient, growth, yield, quality

## INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is an important sugar crop in the world due to relatively short duration, low fertilizer and water requirements compared to sugarcane. The taproot of sugar beet contains 13-22% sugar (Heidari *et al.*, 2008). Increasing sugar yield is a serious demand to meet sugar consumption or at least to decrease the gap between production and consumption of many countries in the world like Bangladesh. The sugar beet-producing dominating countries are Russian Federation, France, Turkey,

Ukraine, USA, Germany, UK, Iran, Belarus, Netherlands, China, Poland, Egypt, Italy, and Belgium (Kumar and Pathak, 2013). The yield ability of sugar beet depends on varietal potentiality along with agro-climatic and edaphic conditions, and also management practices. The importance of this crop comes from its ability to grow in the newly reclaimed soils and provides the growers under low soil fertility with profitable income (Abdel-Motagally, 2015). Fertilizer or nutrient management is the science, practice, and art of understanding the source of

fertilizer, placement, rate, and timing of application since they associate with fertilizer use efficiency and production economics. The nutrient management interacts with different agro-ecological areas and soils which brings about various recommendations for the different nutrients. The soil properties are the important dominating factors for the availability of plant nutrients. Sugar beet uptake of macronutrients (especially N, P, and K) is considerable because it helps in following the natural cycle of the elements. Moreover, the plant

N, P, and K balanced and harmonized requirements of a sugar beet crop could be estimated from the N, P, and K uptake, and hence maximum sugar beet yield could be approached (Wendenburg and Koch, 1996). Although easier to manage than N, maintaining adequate amounts of phosphorus, potassium, sulfur, and micronutrients are also critical for maximizing sugar yields. Sugar beet plant is significantly responsive to micronutrient and its deficiency is one of the most important biotic stresses in plants grown especially on calcareous soils (Abdel-Motagally, 2015). The micronutrient application specifically zinc and boron along with various mixtures of macronutrients may play an important role in the enhancement of yield and quality of tropical sugar beet was reported elsewhere (Bairagi *et al.*, 2013; Kashem *et al.*, 2015; Paul *et al.*, 2018a and Paul *et al.*, 2018b). When deficiencies of nutrients cannot be corrected by the direct applications of the nutrients to the soil, foliar nutrition is an option (Sarkar *et al.*, 2007). Many investigators used the organic matter to fertilize sugar beet. Negm *et al.*, (2003) found that the application of organic manure slightly increased cation exchange capacity, and reduced soil pH. It was also observed that the available N, P and K in the soil increased after the application of organic manure

and reduced gradually by time to harvest. The objectives of this study is to review and reference those works and delineate the existing status of nutrient management for sugar beet, as well as to approach the future needs keeping sugar beet a cost-effective crop for the farmers.

### **RESPONSE OF SUGAR BEET TO VARIOUS NUTRIENTS**

#### **Nitrogen**

Nitrogen as a major constituent of cell plays a vital role in cell division and elongation by virtue of being an crucial part of various type of metabolically active compound like amino acids, proteins, nucleic acids, prophyryns, flavins, purines and pyrimidine nucleotides, enzymes, co-enzymes and alkaloids (Murtaza *et al.*, 2013). Nitrogen (N) is a vital plant nutrient and a major yield and quality influential factor for sugar beet. Managing nitrogen has always been a balancing act for the efficient cultivation of sugar beet. Plants need nitrogen early in the season to put on weight, but too much late can cause sugar levels to fall (Snyder, 2017). Therefore, proper nitrogen management is critical for optimal sugar beet production. Compare to optimum dose the application of too little nitrogen will result in reduced root tonnage, however, the application of

too much nitrogen will result in reduced sugar concentrations and increased impurities (Hergert, 2010).

Nitrogen fertilization significantly increases soil fertility and crop productivity (Ahmad *et al.*, 2017). In case of plant physiology such as leaf area, leaf area index, and photosynthetic rate can improve with the application of nitrogen which can eventually increase the yield (Cai and Ge, 2004). Nitrogen is probably the most studied nutrient for sugar beet because of its direct relationship to yield and it is the nutrient for most limiting plant productivity (Loomis and Conor, 1992). Nitrogen management is sharply linked to soil water relationships (Cariolle and Duval, 2006; Burkhart and Stoner, 2008; Coyne, 2008; Randall and Goss, 2008; Raun and Schepers, 2008). However, the challenging part of N management then arises determining the amount of N required producing the most profitable amount of sugar from the field. Proper N management, the N application, N uptake, and release must occur to allow good early canopy growth (Malnou *et al.*, 2008). Nitrogen management must be maintained in 4–6 weeks before harvest without having excess N (Draycott and Christenson, 2003; Cariolle and Duval, 2006). As harvest approaches, N availability should truly decrease to promote boosted sucrose formation (Loomis and

Nevins, 1963). Geypens *et al.* (1998) reported that due to increasing nitrogen rate more than the recommended dose (80 kg N ha<sup>-1</sup>) increased root yield but decreased sugar content, while Paul *et al.* (2018a) noted that higher dose of nitrogen increased beet yield without significant hampering sucrose content in juice.

Managing N rate, placement and timing can be a challenge because of the uncertainty of precipitation in rainfed areas (de Koeijer *et al.*, 2003). This can have N efficiency and significant effects on N use recovery because of N losses from denitrification or leaching (Coyne, 2008; Mulla and Strock, 2008; Francis *et al.*, 2008). Most N recommendations in rainfed areas of Europe and North America are based on soil analyses.

Nitrogen application in rainfed areas has generally been reduced to spring time before planting through early in the growing season as a means of improving N use efficiency and reducing environmental effects, primarily leaching (Draycott and Christenson, 2003). In many irrigated areas, soils are developed under semiarid conditions and organic matter in soil levels are low resulting in low N mineralization (Carter and Traveller, 1981; Anderson and Peterson, 1988; Bilboa *et al.*, 2004). Depth of root under irrigation often reaches at least 1.2 m, but often extends below 1.8 m

(Peterson *et al.*, 1979). It was established in early research the importance of this means of improving N recommendations (Gilbert *et al.*, 1981) and some other work established N uptake of sugar beet from deeper levels (Anderson *et al.*, 1972). In Spain, pre plant measurement of soil nitrate in irrigated areas has also proven to be very effective in separating between responsive and non-responsive sites (Bilboa *et al.*, 2004). It was established that of 39 mg kg<sup>-1</sup> was the critical level for maximizing root and sucrose yield. When a price correction was applied for sucrose content (a practice common in Spain and the US), the critical level was 33 mg kg<sup>-1</sup>. Above citation indicate that nitrogen is a vital nutrient for sugar beet and its management is very important for maximizing yield and quality.

### Phosphorus

Phosphorus is a crucial element determining plants' growth and productivity by playing a vital role in cellular processes (Malhotra *et al.*, 2018). Phosphorous is a component of nucleic acids and lipids and is important in the production and transport of sugars, fat and protein during sugar beet production (Ghaly *et al.*, 2019). It is a critical macronutrient required for numerous functions in plant, including energy generation, nucleic acid synthesis, photosynthesis, glycolysis, respiration,

carbohydrate metabolism and nitrogen fixation (Abel *et al.*, 2002). Phosphorus is the second most limiting nutrient in comparison to nitrogen for sugar beet cultivation (Malhotra *et al.*, 2018). It is especially important during early root development which ensures rapid root growth and good uptake of other nutrients. Phosphorus helps in the transfer of energy within the plant cells and moreover it regulates the structural integrity of cell membrane (Ahmad *et al.*, 2017). Phosphorus deficient plants appear stunted, stiff appearance with darker green to dull blue-green leaves (Uchida, 2000). Phosphorus deficiency associated with soils in high pH and low in organic matter. Ismail *et al.* (2007) and Ouda (2007) reported that fresh and dry weights, leaf area index and root and sugar yields, as well as sucrose percent and sugar loss to molasses were increased as phosphorus rate increased up to 30 kg P<sub>2</sub>O<sub>5</sub> fed<sup>-1</sup>. Abdou *et al.* (2008) stated that increasing phosphorus fertilizer levels from 0.0 up to 30 kg P<sub>2</sub>O<sub>5</sub> fed<sup>-1</sup>, markedly increased root weight by 10.80 and 10.82 %, root yield by 17.56 and 17.72 % and sugar yield by 29.31 and 29.52 % in the first and second seasons, respectively while Marinković *et al.* (2008) showed that increasing P<sub>2</sub>O<sub>5</sub> from 50 to 100 and 150 kg ha<sup>-1</sup> resulted significantly increased root and sugar yields. Seadh (2012) reported that application of 30

kg  $P_2O_5$  fed<sup>-1</sup>, produced the highest values of growth characters and the highest values of the root, top, and sugar yields. Madani *et al.* (2014) explored that phosphorous fertilizer had a significant effect on sugar yield and the highest sugar yield (0.98 kg/m<sup>2</sup>) was recorded when fertilized with 375 kg/ha ammonium superphosphate as a source of phosphorous. Adding 31.0 kg  $P_2O_5$  fed<sup>-1</sup> maximize sugar beet root yield and quality (Abdou *et al.*, 2014). Hussain *et al.* (2014) declared that the addition of phosphorus increased beet yield by 37 and 47% over control and Ghaly *et al.* (2019) noted that optimum phosphorus rate is 48 kg  $P_2O_5$  fed<sup>-1</sup> for efficient sugar beet cultivation. Results indicate phosphorus fertilization increased beet yields and quality. Therefore, growers should be maintained optimum dose of phosphorus to maximize beet and sugar yields.

### Potassium

Sugar beet is known as high potassium requiring crop (Johanson *et al.*, 1971). According to assessments of Malakuoti (2000) potassium in plants has the role of catalyst and its shortage reduces resistance in plants against pests and plant diseases. Potassium has been shown to greatly improve early vigor and growth of sugar beets, particularly when producing optimum yield. Potassium

plays an important role in the transport of metabolites in the phloem, particularly into storage tissues. Plants that accumulate large reserves of protein, carbohydrate, and sugar in their storage tissues have high K requirements. Potassium is the most abundant cation in plant tissues which has an essential role in metabolism (Mangel and Kirby, 2001). Potassium and its accompanying anions have a major contribution to the osmotic potential of cells and tissues of glycophytic plant species. It has a role in the nutritional balance that increases the organic compounds through the photosynthesis (El-Harriri and Gobarh, 2001, Gobarh and Thalooh, 2001). Dry weights and fresh weight of shoot and root were significantly affected by increasing the potassium level. The increase of fresh and dry weights of shoot and root caused by potassium fertilization could be attributed to the effect of K on the photosynthesis process in the plants and in turn, the translocation of sugar and carbohydrates of assimilates from tops to roots, which lead to increases in the root and sugar yield (El-Kholy *et al.*, 2006). Potassium moves from older tissues to the growing points of the roots and tops since it is a mobile element in plant tissues. The beneficial effect of K fertilization on growth, yield, and quality of sugar beet was highlighted elsewhere (El-

Shafai, 2000; Zalut and Youssif, 2001; Attia, 2004; Abdel-Motagally and Attia, 2009 and Abdel-Motagally, 2009). The increase in recoverable sugar yields may be attributed to the role of K in nutrient uptake and nutritional balance which increases organic compounds through the photosynthesis process (Attia, 2004). Similar results were reported by Abdel-Motagally (2009), Abdel-Motagally and Attia (2009) and El-Sarag *et al.* (2013). Awad *et al.* (2013) stated that application of potassium @ 48 kg  $K_2O$ /fed resulted in a substantially increase in leaf area index and dry matter accumulation plant<sup>-1</sup>, root length, root diameter, root weight, root yield, top yield, total soluble solids (TSS) and white sugar yield compared to other treatments. Potassium application @ 100 kg  $K_2O$  ha<sup>-1</sup> increased root yield, shoot yield, impure sugar percent, pure sugar percent and sugar yield under full and deficit irrigation over control (Mehrandish *et al.*, 2012) while Kashem *et al.* (2015) noted that application of potassium significantly increased root and sugar yield and for appreciable yield tropical sugar beet requires more than 180 kg K ha<sup>-1</sup>. Therefore, the highest potassium uptake by beet plants exerts the highest effect on yields of storage roots. Potassium uptake rate by beet plants might be is a prerequisite for an efficient



uptake and function of N. Excess of soil available K may lead to prolonged growth of tops. Above reviews indicate that potassium is a very important plant nutrient for sugar beet in terms of root yield and juice quality.

### Sulphur

Sulphur is often referred to as the fourth major plant nutrient as it is an essential component of important metabolic and structural compounds (Thomas *et al.*, 2003). Sulfur deficiencies in sugar beet are usually a yellowing of the leaf canopy. Sulfur deficiency in sugar beet results in a decrease of CO<sub>2</sub> uptake and assimilation (Terry, 1976). As sulfur decreases below a critical level, chlorophyll content decreases which in turn decreases photosynthesis (Resurreccion *et al.*, 2001). Compared to cereals and oil seed crops, sugar beet has a relatively low sulphur requirement (Syers *et al.*, 1987) although it does have a requirement for a continual input of sulphur throughout the growing season to support the continued leaf growth and storage root development (Thomas *et al.*, 2003). Response to sulfur fertilizers on sugar beets in irrigated areas is quite small because irrigation water often contains sufficient sulfate to meet S requirements. This problem was noted in California (Ulrich and Hills, 1969) but has not been reported as a concern in

recent US research (Draycott and Christenson, 2003). If sugar beets are grown on soils with less than 1% organic matter and irrigation water levels of sulfate are less than 6 mg/kg, 10 kg/ha S may be applied. In higher rainfall areas of the USA, there have not been significant increases from sulphur application (Draycott and Christenson, 2003). Application of sulphur (25 kg ha<sup>-1</sup>) resulted in a 25% increase in root yield together with significant increases in root and shoot dry matter accumulation (Thomas *et al.*, 2003). El- Kammah and Ali (1996) and Hashem *et al.* (1997) indicated that yields of roots and sugar were significantly increased with increasing levels of applied sulphur. Application of 46 kg S ha<sup>-1</sup> along with other regular nutrients to sustain better root and sugar yields (Zengin *et al.*, 2009). Sugar beets received 250 kg S fed<sup>-1</sup> produced the highest root and sugar yield was reported by Awad *et al.* (2013). Reviews have shown that sugar beet has a reasonably high demand of sulphur for enhancement its yield and quality. Therefore, proper management of sulphur is necessary for yield and quality improvement of sugar beet.

### Zinc

Zinc is an essential micronutrient and it acts a stimulant in different types of enzyme systems which used for protein synthesis and

carbohydrate metabolism (Madani *et al.*, 2014). It is involved in different regulating key growth processes as it helps in the chloroplast development and in the metabolism of auxins (plant growth regulators). Enan (2004) stated that the role of Zn in assisting the utilization of phosphorus and nitrogen in plants might be responsible for the increase in top and root fresh weights gained by Zn application. Similarly the role of Zn in the metabolism of carbohydrates in plants may be influenced the increase in dry weight plant<sup>-1</sup> by Zn application. According to Abdel-Motagally (2009) and Menisy (2009), top and root dry weights of sugar beet increase through the foliar spray with Zn, Mn and Fe chelate. The beet yield increased by 14.5% and 21.8% over control with the application of 1.5 and 2.0 Zn kg ha<sup>-1</sup>, respectively (Barlóg *et al.*, 2016) and Zn @ 0.5 kg ha<sup>-1</sup> significantly increased sugar yield compared to the control. Beet yield, sucrose percentage increase by the foliar application of Zn up to 150 mg/l significantly whereas it decreases impurities in molasses (Attia and Abdel-Motagally, 2015). Abd El-Gawad *et al.* (2004) found that the K content of sugar beet root is increased significantly by the foliar application of Zn. In addition, there is a significant effect of the foliar application of Zn on the sugar loss to molasses. Stevens and Mesbah (2004) applied Zinc fertilizer through

broadcast, foliar, and seed-row application methods where seed-row-applied  $\text{ZnSO}_4$  ( $\text{ZnSO}_4$  at 6 lb acre<sup>-1</sup>, Zn at 2 lb acre<sup>-1</sup>) showed significant effect on root yield over the three year study and in comparison to control resulting in an 11% (2.8 t acre<sup>-1</sup>) root yield increase. Application 5 kg ha<sup>-1</sup> zinc on sugar beet significantly increased the yield and quality of sugar beet; the rate of increase was in the range of 4.62–6.97% in root yield, 2.09–5.75% in sugar percentage, 2.60–8.03% in white sugar percentage and 7.84–13.06% in white sugar yield (Piskin, 2017). Many researchers reported the beneficial effect of Zn fertilizer application as a foliar application on the sugar beet yield (Nemeat- Alla and El-Geddawy, 2001; Enan, 2004; Menisy, 2009) who noticed that the highest applied level of Zn (150 mg l<sup>-1</sup>) as a foliar spray results in an increase in yield or quality of sugar beet plants in calcareous sandy soils. Results indicate that sugar beet yield and quality are significantly influenced by soil or foliar application of zinc..

### Boron

Boron plays an essential role in promoting cell wall formation, carbohydrate metabolism, and has been associated with sugar translocation (Ahmad *et al.*, 2009). Boron deficiency has been understood as the second most vital micronutrients constraints in

crop production after zinc. Sugar beet generally considered having relatively high requirements of boron as compared to other commodities (Tlili *et al.*, 2018). It is primarily associated with production and transport of sugars to actively growing and developing roots of sugar beet (Barker and Pilbeama, 2007). Boron is by far the most important of the trace elements needed sugar beet because, without an adequate supply, the yield and quality of roots are very depressed. Soil application, as well as, a foliar spray of boron is equally effective, hence the fresh root weight, sucrose %, root and top yields significantly increased by increasing boron levels. Armin and Asgharipour (2012) reported that the highest root yield and sucrose concentration was obtained by spraying with 12% boric acid. Soliman *et al.* (2014) showed that boron as foliar application significant responses in growth characters of sugar beet and exerted a significant increase in sugar, juice purity and crude protein percentage. Islam *et al.* (2015) reported that basal application of Boron @ 1.5 kg ha<sup>-1</sup> increased beet yield, juice quality as well suppressed of crown rot incidence of tropical sugar beet. Abido (2012) stated that root yield and sugar content of sugar beet were increased with the application of boron @ 80 ppm. Applying boron @ 0.20

to 0.25 g L<sup>-1</sup> twice at 80 and 110 days after planting the beet yield and quality were increased with foliar application of boron. Due to B application sugar yield recorded 7.52 t fed<sup>-1</sup> and 9.42 t fed<sup>-1</sup> which were 65.17% and 46.14% higher respectively, compared to control treatment (Abbas *et al.*, 2014). Application of boron solution @ 100 ppm at 70 days after planting (DAP) proved beneficial as it increased yield and quality of sugar beet (Abdel-Motagally, 2015). According to Al-Mohammad and Al-Gaddawi (2001), heart rot disease reduced significantly with the boron consumption of sugar beet when applied @1.2 kg B ha<sup>-1</sup>. At the same time, due to increased glucose levels in roots and phloem sap, the sugar yield also increased. On the other hand Abdel-Motagally (2015) carried out an experiment with boron concentrations (0, 50 and 100 ppm) and various time of application (35, 70 and 105 days after planting, DAP), and the author found that boron, yield and quality traits of sugar beet were significantly increased by high concentration of boron. Narayan *et al.*, (1989) stated that the highest yield of top (18.6 t ha<sup>-1</sup>) and beet (49.58 t ha<sup>-1</sup>) were produced through the basal application of boron @ 20 kg borax ha<sup>-1</sup> (2.27 kg B ha<sup>-1</sup>). Moreover, with the same treatment, it produced 14.92% sucrose in beet juice, total sugar content as well as at the same time improved

the quality of sugar beet. Cooke and Scott (1993) reported that boron acts as the most important trace element demanded essentially by sugar beet. According to Gobarah and Mekki (2005) root length, diameter and root yield of sugar beet were increased with the application of boron @ 1.5 kg B acre<sup>-1</sup>. Bithi (2019) found that 150 ppm boron applied thrice at 40, 65 and 90 days after emergence is very effective for maximizing the beet yield, juice quality and suppression of crown rot incidence of sugar beet. Above results reveals that boron has tremendous influence on sugar beet yield and quality of juice. Both soil and foliar application of boron are effective in sugar beet. Therefore, an adequate supply of boron micronutrient is required to efficient cultivation of sugar beet.

#### **Manganese and other micro nutrients**

Manganese is an essential micronutrient with many functional roles in plant metabolism. It is a cofactor for enzymes involved in hydrolysis, phosphorylation, decarboxylation, and transamination (Schmidt and Husted, 2019). Manganese helps in the production of enzymes used for metabolism of proteins and fat. Application of manganese @ 25-30 kg ha<sup>-1</sup> together with compound fertilizer increased the average root yield by 2.0 t ha<sup>-1</sup>

(+7%) compared to manganese-free compound fertilizer (Erjala, 1986). Mekki (2014) reported that Manganese as sole treatment increased root length and diameter as well as fresh root weight of sugar beet. El-Sherief *et al.* (2016) reported that the purity percentage significantly increased @ 2.0 kg fed<sup>-1</sup> Mn application. Iron, Mn and Zn concentrations and uptakes by sugar beet roots significantly increase with increasing the foliar spray with Zn from 75 to 150 mg l<sup>-1</sup> in comparison with the control treatment (Attia and Abdel-Motagally, 2015). Gobarb and Thaloorth (2001) found that some micronutrients such as Fe, Mn and Zn was important in meeting their deficiencies during the growth period as well as to increase yield components and yield quality of sugar beet. Gobarah *et al.* (2014) stated that the highest productivity and quality of sugar beet were produced by spraying micronutrients mixture (Fe+Zn+Mn+B) twice at 60 and 90 days after sowing @ 50ppm for each in the form of (Zinc sulphate, Manganese sulphate and Boric acid) and 100ppm in the form of Iron sulphate. Masri and Hamza (2015) stated that foliar application of the increasing levels of Zn+Mn+Fe+B micronutrients increased yield attributes, beet yield, the total soluble solids (TSS), sucrose %, purity % and extractable sucrose % of from sugar beet. In conclusion, Mn along

with other micronutrients like Zn, Fe, B significantly influence beet yield and various quality parameters of sugar beet.

#### **RESPONSE OF SUGAR BEET TO MANURE AND INTEGRATED FERTILIZATION**

Organic manures are considered to produce higher crop productivity for sustainable agriculture. It provide nutrients to the soil and improve water holding capacity thus assist the soil to maintain better aeration for seed germination and plant root development (Zia *et al.*, 1998). Hergert and Nielsen (2011) stated that of manure increased sugar yield significantly with no significant effect on sugar loss to molasses. Manure could be a valuable source of nutrients for sugar beet because it mineralizes slowly which can affect sugar content and impurities (Paul *et al.*, 2018b). Topcuoğlu and Önal (2005) reported that poultry manure increased total yield and sugar content in sugar beet. The best application level of poultry manure was found at 10 t ha<sup>-1</sup>, but at the 40 t ha<sup>-1</sup> poultry manure applications yield was declined. Gary *et al.* (2016) found that application of manure 20 t ha<sup>-1</sup> increased sugar yield by 10% with no significant effect on sugar loss to molasses while Al-Labbody (1998) stated that increasing farmyard manure from 4.01 to 9.6 t fed<sup>-1</sup> significantly

increased sucrose % and sugar yields. Although Kopczynski *et al.* (1999) found that application of vermicompost increased the yield of roots and sugar and enhanced the content of sugar in roots and, Zalat and Nemeat Alla (2001) confirmed that adding 6 tons farmyard manure/fed gave the highest values of sucrose% (SC%) and total soluble solids (TSS%). El-Agrodi *et al.* (2011) noticed that that root quality parameters such as SC%, TSS%, purity and sugar yield significantly increased with chicken manure over the control and chicken manure along with gypsum significantly increased root yield. Marinhovic *et al.* (2004) found that the application of organic fertilizer increased the yield from 1.41 to 2.13 t ha<sup>-1</sup>. Similarly, Hassan (2005) indicated that the application of the organic fertilizers induced increases in the root yield, sugar yield, sucrose content, purity % and the concentrations of NPK and micronutrients (Fe, Mn and Zn) in roots. In addition, Paul *et al.* (2018b) reported that sugar beet fertilized with 75% recommended dose of NPK and other inorganic fertilizers + poultry manure @ 2.5 increased beet yield

compared to sole application of inorganic fertilizers and poultry manure. Balakrishnan and Selvakumar (2008) stated that application of 100 per cent N through Urea along with FYM and biofertilizer provided the superior result in terms of tropical sugarbeet emergence, establishment, yield and quality although Hasanen *et al.* (2013) reported that supplying sugar beet with 350 kg N fed<sup>-1</sup> with FYM or PM resulted in the highest root and sugar yields fed<sup>-1</sup>. Sohel (2016) noted that combined application of inorganic fertilizer Urea-TSP-MoP @ 260, 100, 225 kg along with cowdung @ 10 t ha<sup>-1</sup> contributed the highest beet yield (90.49 t ha<sup>-1</sup>). Above results indicated that sole application of manure or integration of manure with inorganic fertilizers increased yield and juice quality of sugar beet. Therefore, sugar beet growers can be used manures to curtail inorganic fertilizers as well as improvement of yield and juice quality of sugar beet.

### CONCLUSIONS

Improving sugar beet productivity is a serious concern to the production of sugar for ever increasing population. The application of macro and micronutrients

through fertilization is important for maximizing sugar beet productivity. The dose, timing, and method of application of those nutrients influence the yield performance of sugar beet. Above review of the literature mentioned that among the micronutrients Zn and B are highly responsive to sugar beet along with other macro nutrients like N, P, K and S and all of them have a tremendous influence on the growth, yield components, yield, and juice quality of sugar beet. Combined application of manure and inorganic fertilizer also influence root yield and quality of sugar beet. It seems that proper nutrient management is very essential to maximizing beet yield, sucrose yield, and also minimizes impurities in juice. Therefore, nutrient management is a critical factor in terms of yield and quality of sugar beet that should be considered to profitable sugar beet cultivation.

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